Lifting lug on 9.4T 210 OVC.

Total weight of magnet: $M := 5000kg$

Four lugs - distrbution of load using chains can mean any one lug may be required to take half the total weight.

Load on each lifting lug: $P := \frac{M \cdot g}{2}$ $P = 24516.63\,N$

Material: - Stainless Steel 304

Ultimate tensile stress: $UTS := 485 \cdot 10^{6} Pa$ Proof Stress: $R_{0.2} := 170 \cdot 10^{6} Pa$

Allowable design stress
for a safety factor of 4 on UTS: $\sigma_{max} := \frac{UTS}{4}$ $\sigma_{max} = 121.25 \times 10^{6}\,Pa$

Plate geometry:

Plate thickness: $t := 12mm$

Effective width of tensile loaded plane: $b := 35mm$

Effective area of tensile loaded plane: $A := 2 \cdot t \cdot b$ $A = 840\,mm^{2}$

Stress in vertical lift: $\sigma_{v} := \frac{P}{A}$ $\sigma_{v} = 29.19 \times 10^{6}\,Pa$

This is safely below allowable design stress

Minimum weld area: Allowable shear stress in weld: $AWS := 0.3 \cdot UTS$ $AWS = 1.455 \times 10^{8}\,Pa$

Area of weld required: $A_{weld} := \frac{P}{AWS}$ $A_{weld} = 168.499\,mm^{2}$

Actual weld area:
Leg of base weld: $z_b := 5mm$
(To OVC tube)

Throat of base weld: $a_b := \frac{\sqrt{2 \cdot z_b^{2}}}{2}$ $a_b = 3.54\,mm$

Length of base weld: $l_b := 73mm$

Area of base weld: $A_b := a_b \cdot l_b$ $A_b = 258.09\,mm^{2}$

Leg of top welds: $z_t := 4mm$ (Ignoring chamfer)

Throat of top welds: $a_t := \frac{\sqrt{2 \cdot z_t^{2}}}{2}$ $a_t = 2.83\,mm$

Total length of
top welds: $l_t := 75mm$

Area of top welds: $A_t := a_t \cdot l_t$ $A_t = 212.13\,mm^{2}$

Total area of welds: $A_{Total} := A_b + A_t$ $A_{Total} = 470.226\,mm^{2}$

Therefore exceeds minimum area required.

Limits of horizontal loading:

Distance from point of lift to top weld: $l_1 := 91mm$
(Centre of area of top weld)

Distance from top weld to base weld: $l_2 := 38mm$
(Centre of areas of welds)

Maximum horizontal load, limited by top weld:

Maximum reaction at top weld: $F_t := AWS \cdot A_t$ $F_t = 30.865 \times 10^3 N$

Maximum horizontal load, limited by plate bending:

Effective beam width: $b_e := 93mm$

Moment of inertia: $I := b_e \cdot \frac{t^3}{12}$ $I = 1.339 \times 10^{-8} m^4$

Stress limited by allowable stress:

Maximum bending moment: $M_{max} := \frac{\sigma_{max} \cdot 2 \cdot I}{t}$ $M_{max} = 270.63 N \cdot m$

Maximum horizontal load: $P_h := \frac{M_{max}}{l_1}$ $P_h = 2973.956 N$

Maximum angle of chain: $\alpha := asin\left(\frac{P_h}{P}\right)$ $\alpha = 7 deg$

Stress limited by yielding:

Maximum bending moment: $M_{max} := \frac{R_{0.2} \cdot 2 \cdot I}{t}$ $M_{max} = 379.44 N \cdot m$

Maximum horizontal load: $P_h := \frac{M_{max}}{l_1}$ $P_h = 4169.67 N$

Maximum angle of chain: $\alpha := asin\left(\frac{P_h}{P}\right)$ $\alpha = 9.8 deg$

The lifting chains should be kept vertical when viewed from the side of the system, as they can only safely tolerate an angle of 7^{o} from vertical.